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Indian Standard

SPECIFICATION FOR CERAMIC DIELECTRIC CAPACITORS, TYPE 2

PART I GENERAL REQUIREMENTS AND METHODS OF TEST

(First Revision)

UDC 621·319·4 : 621·315·612 : 620·1 : 621·38/·39

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PART I GENERAL REQUIREMENTS AND METHODS OF TEST

(First Revision)

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Indian Standard

SPECIFICATION FOR CERAMIC DIELECTRIC CAPACITORS, TYPE 2

PART I GENERAL REQUIREMENTS AND METHODS OF TEST

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) (Part I) was adopted by the Indian Standards Institution on 5 May 1978, after the draft finalized by the Capacitors Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This Standard (Part I) lays down test methods and general requirements for judging the performance of ceramic dielectric capacitors with a high permittivity (Type 2) suitable for by-pass and coupling application or for frequency discriminating circuits where low losses and high stability of capacitance are not of major importance.

0.3 This standard was originally published in 1965, and then amended in 1969. Subsequently methods of tests for all types of capacitors are grouped in IS : 7305 (Part I)-1973*. This standard is revised with a view:

a) to bring it in line with latest IEC documents on the subject and IS : 7305 (Part I)-1973*, which is a necessary adjunct to this standard;
b) to review the climatic categories and change in refree temperature based on the latest technological improvements;
c) to review the schedule of type tests and number of samples required;
d) to review the schedule of acceptance tests, AQL values and inspection levels; and
e) to improve certain performance requirements.

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*Specification for fixed capacitors used in electronic equipment: Part I General requirements and tests.

0.4 While preparing this standard assistance has been derived from the following:

IEC Doc: 40 (Sectt) 278 Draft — fixed capacitors of ceramic dielectric, Type 2. Selection of methods of test and general requirements, issued by International Electrotechnical Commission.

JSS: 50203 - 1971 Detail specification for capacitors, fixed, ceramic dielectric, general purpose, issued by Directorate of Standardisation. Department of Defence Production, Ministry of Defence, New Delhi.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part I) prescribes general requirements and test methods for ceramic dielectric capacitors, type 2 with a high permittivity including leadless capacitors intended for use in electronic and telecommunication equipment.

1.1.1 Capacitors for radio frequency currents exceeding 1A or for a reactive power exceeding 200 VAR are not covered by this standard.

2. TERMINOLOGY

2.1 For the purpose of this standard, the following terms and definitions, in addition to those covered in IS : 7305 (Part I)-1973† apply.

2.1.1 *Type 1 Capacitors* — Capacitors suitable for use in resonant circuits or any other applications where low losses and high stability are essential.

2.1.2 *Type 2 Capacitors* — Capacitors suitable for by-pass and coupling applications or in frequency discriminating circuits where low loss and high stability of the capacitors are not of major importance. The ceramic dielectric is characterised by the maximum change of capacitance in percent over the category temperature range (*see* Table 1 and **5.1.1**).

3. STABILITY CLASSIFICATION

3.1 Five stability classes of ceramic dielectric capacitors, type 2 combined with temperature ranges (*see* **4.2**) are given in Table 1. The permissible maximum capacitance changes in percent, within the category

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*Rules for rounding off numerical values (*revised*).

†Specification for fixed capacitors used in electronic equipment: Part I General requirements and tests.

temperature range, with or without voltage application, are given with respect to the capacitance, at 27°C without any voltage applied.

TABLE 1 STABILITY CLASSIFICATION

(*Clauses* 2.2, 3.1, *and* 9.3.5.4)

LETTER CODE	MAXIMUM CAPACITANCE CHANGE IN PERCENT		CATEGORY TEMPERATURE RANGES			
	Without Voltage Applied	With Rated dc Voltage Applied	−55/ +125°C	−55/ +85°C	−40/ +85°C	−10/ +70°C
(1)	(2)	(3)	(4)	(5)	(6)	(7)
B	± 10	$^{+10}_{-15}$	—	×	×	×
C	± 20	$^{+20}_{-30}$	×	×	×	—
D	$^{+20}_{-30}$	$^{+20}_{-40}$	—	—	—	×
E	$^{+20}_{-55}$	$^{+20}_{-70}$	—	×	×	—
F	$^{+30}_{-30}$	$^{+30}_{-90}$	—	×	×	—

4. CLIMATIC CATEGORIES

4.1 The ceramic dielectric capacitors, type 2, covered in this standard are classified into climatic categories according to the general rules given in IS : 589-1961*.

4.2 Capacitors covered by this standard shall belong to one of the preferred climatic categories given in Table 2, based on their ability to withstand the climatic severities.

5. RATINGS

5.1 Rated Capacitance — The value of rated capacitance (C_R) shall be chosen from E6 and E12 series of IS : 824-1965†.

5.1.1 *Tolerance on Rated Capacitance* — The permissible tolerances on rated capacitance values shall be chosen from the following:

Tolerance		*Preferred Series* (see *IS : 824-1965*†)
For $C_R > 10$ pF	For $C_R \leqslant 10$ pF	
+ 80 percent − 20 percent + 50 percent − 20 percent ± 20 percent	± 1 pF	E6
± 10 percent	± 1 pF	E12

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*Basic climatic and mechanical durability tests for electronic components (*revised*).

†Preferred values for resistors and capacitors (*revised*).

TABLE 2 CLIMATIC CATEGORIES

(*Clause* 4.2)

Sl No.	Climatic Test (IS : 589-1961*)	Severities			
		Category 1		Category 2	Category 3
		A	B		
(1)	(2)	(3)	(4)	(5)	(6)
i)	Dry heat	+125	85°C	+85°C	+70°C
ii)	Cold	−55°C	−55°C	−40°C	−10°C
iii)	Damp heat (long term)	56 days	56 days	21 days	10 days
iv)	Damp heat (accelerated)	6 cycles	6 cycles	2 cycles	1 cycle
v)	Rapid change of temperature	+125 to −55°C	+85 to −55°C	+85 to −40°C	Not applicable
vi)	Low air pressure	4·4 kPa	4·4 kPa	8·5 kPa	60 kPa

Note — In case of special requirements where the above categories cannot be applied strictly the other combinations of severities may be agreed to between the manufacturer and the purchaser provided such severities are chosen from IS : 589-1961*.

*Basic climatic and mechanical durability tests for components for electronic and electrical equipment (*revised*).

5.2 Rated Voltage — The values of dc rated voltage shall be chosen from the following:

12·5, 25, 31·5, 40, 50, 63, 100, 125, 160, 250, 400, 500, 630, 1 000 and 1 600V.

Note — The values of rated voltage are derived from R5 and R10 series of IS : 1076-1961*.

6. CONSTRUCTION AND WORKMANSHIP

6.1 The construction and workmanship shall be in accordance with **5** of IS : 7305 (Part I)-1973†.

7. DIMENSIONS

7.1 The dimensions shall conform to those specified in the relevant detail specification.

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*Preferred numbers (*first revision*).

†Specification for fixed capacitors used in electronic equipment: Part I General requirements and tests.

8. MARKING

8.1 The following information in order of importance shall be clearly marked on the capacitor:

a) Rated capacitance (may be in a coded form according to IS : 8186-1976*),

b) Tolerance on rated capacitance value (may be in a coded form according to IS : 8186-1976*),

c) Rated voltage,

d) Stability class,

e) Manufacturer's name or trade-mark,

f) Indication of appropriate category according to this standard,

g) Week (or month) and year of manufacture (may be in a coded form according to IS : 8186-1976*),

h) Style reference (as given in relevant detail specification),

j) Manufacturer's type designation, and

k) Any other marking if required by the purchaser.

8.1.1 Each capacitor shall be clearly marked with (a), (b) and (c) and with as many as possible of the remaining items in the order given in **8.1**.

8.1.2 The package, containing the capacitor(s) shall be clearly marked with all the information listed in **8.1**.

8.1.3 Any additional marking on the capacitor or its package or both shall be so applied that no confusion may arise.

8.2 The capacitors or its package may also be marked with ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

9. TESTS

9.1 Classification of Tests

9.1.1 *Type Tests*

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*Marking codes for values and tolerances of resistors and capacitors.

9.1.1.1 *Type approval procedure* — The procedure for type approval shall be in accordance with IS : 2612-1965*.

9.1.1.2 *Number of samples* — Unless otherwise specified, the number of samples for each type shall be 24 or 28 (*see* Table 3).

TABLE 3 SCHEDULE OF TYPE TESTS

(*Clauses* 9.1.1.2, 9.1.1.3 *and* 9.1.1.4)

GROUP	NUMBER OF SAMPLES		TITLE OF TESTS	REF TO CLAUSE
	Each Temperature Characteristic, Each Operating Temperature Range and Each Voltage in a Style	Only One Temperature Characteristic, Operating Temperature Range in Each Voltage in a Style		
(1)	(2)	(3)	(4)	(5)
0	24	28	Visual examination	9.4.1
			Dimensions	9.4.2
			Capacitance	9.3.1
			Tangent of loss angle	9.3.2
			Voltage proof (one minute)	9.3.4
			Insulation resistance	9.3.3
4	6	6	Solderability	9.4.4.1
			Robustness of terminations	9.4.3
			Resistance to soldering heat	9.4.4.2
			Bump	9.4.6
			Vibration	9.4.5
			Shock	9.4.7
			Acceleration (steady state)	9.4.8
			Rapid change of temperature	9.5.3
			Climatic sequence	9.5.1
2	6	6	Damp heat (long term)	9.5.2
3	4	8	Temperature characteristic of capacitance	9.3.5
			Endurance	9.6.2
4	2	2	Mould growth	9.5.5
5	3	3	Resistance to solvents	9.6.3
			Resistance to soldering heat	9.4.4.1
6	2	2	Salt mist	9.5.4
Spares	1	1		

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*Recommendation for type approval and sampling procedures for electronic components.

9.1.1.3 *Selection of samples* — The samples shall be representative of the range of values of the type under consideration. Samples shall comprise quantities in the closest voltage temperature characteristic in each voltage rating and operating temperature range in each style. The samples shall be of the highest capacitance and closest tolerance in each voltage temperature characteristic.

NOTE — A capacitor subjected to type tests according to Table 3 shall not be used in the equipment nor be returned to bulk supply.

9.1.1.4 *Schedule of type test* — The capacitors shall be subjected to the tests specified in Table 3, in the given order. After the completion of tests specified under group 0, the samples shall be divided into six groups for further testing.

9.1.2 *Routine Tests* — The following tests shall be carried out on each capacitor:

a) Visual examination,

b) Voltage proof (as a flash test), and

c) Capacitance.

9.1.3 *Acceptance Tests* — Two group of samples (groups A and B) shall be selected (*see* Appendix B of IS : 2612-1965*) from the lot which has passed the routine tests as specified in **9.1.2** and the capacitors in each group shall be subjected to the tests specified in Table 4 in the given order.

9.2 General Conditions for Tests — The general conditions for tests shall be in accordance with **7.2** of IS : 7305 (Part I)-1973†, with the following addition to preconditioning.

9.2.1 *Special Preconditioning* — This shall be for one hour at the upper category temperature or at such higher temperature as may be specified in the relevant detail specification, followed by a recovery period of 24 hours. This replaces drying according to **7.2.4** of IS : 7305 (Part I)-1973†.

NOTE — Type 2 capacitors lose capacitance continuously with time according to logarithmic law (this is called ageing). However, if the capacitor is heated to a temperature above the curie point of its dielectric, then 'de-ageing' takes place, that is, the capacitance lost through 'ageing' is regained and the 'ageing' recommences from the time when the capacitor recools. The purpose of this special preconditioning is to bring the capacitor to a defined state regardless of its previous history (*see* Appendix A).

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*Recommendation for type approval and sampling procedure for electronic equipment.

†Specification for fixed capacitors used in electronic equipment: Part I General requirements and tests.

TABLE 4 SCHEDULE OF ACCEPTANCE TESTS

(*Clause* 9.1.3)

TEST	REF TO CLAUSE	AQL* (PERCENT DEFECTIVE)	INSPECTION LEVEL	D/ND
(1)	(2)	(3)	(4)	(5)
Group 'A' Tests				
Dimensions	9.4.2	1 percent	II	ND
Tangent of loss angle	9.3.2			
Insulation resistance	9.3.3			
Group 'B' Tests				
Sub-group I				
Temperature characteristics of capacitance	9.3.5	4 percent	S3	ND
Sub-group II				
Solderability	9.4.4.1	4 percent	S3	D
Robustness of terminations	9.4.3			
Bump	9.4.6			
Climatic sequence	9.5.1			
Sub-group III				
Endurance (168 h)	9.6.2	4 percent	S3	ND

ND = Non-destructive.

D = Destructive.

*IS : 2500 (Part I)-1973 Sampling inspection tables : Part I Inspection by attributes and by count of defects (*first revision*).

9.3 Electrical Tests

9.3.1 *Capacitance* — This test shall be carried out in accordance with **7.3.2** of IS : 7305 (Part I)-1973* with the following additional details/modifications:

a) *Measuring conditions* — The capacitance shall be measured with the help of bridge or any other suitable means and corrected, if necessary by calculation, to the reference temperature of 27°C using the nominal temperature coefficient. The standard frequency for measurement shall be 1 kHz ± 10 percent for $C > 100$ pF or 1 MHz ± 10 percent for $C \leqslant 100$ pF. The applied voltage shall be less than 5 V.

NOTE — When measurements are made before and after test, the apparatus and method employed shall be the same in each case.

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*Specification for fixed capacitors used in electronic equipment: Part I General requirements and tests.

b) *Accuracy* — The measuring method shall be such that the error does not exceed:

   i) 10 percent of the tolerance on the rated capacitance for absolute capacitance measurement.

   ii) 10 percent of specified maximum change of capacitance for measurement of variation of capacitance.

NOTE — Temperature variation due to handling shall be avoided.

c) *Requirement* — The capacitance value shall correspond with the rated capacitance, taking into account the tolerance. For referee measurements the capacitance value shall be the value after an ageing time of 1 000 hours (*see* Appendix A).

9.3.2 *Tangent of the Loss Angle (Tan δ)* — This test shall be made in accordance with **7.3.3** of IS : 7305 (Part I)-1973* with the following additional details/modifications.

a) *Accuracy* — The measuring instrument shall have an accuracy of the order of 0·001.

b) *Requirements* — The tangent of loss angle shall not exceed $350 \cdot 10^{-4}$.

NOTE — The tangent of loss angle shall not be measured within 30 minutes of application of a dc voltage, for example, as applied in measurement of insulation resistance.

9.3.3 *Insulation Resistance (R_1)* — This test shall be carried out in accordance with **7.3.6** of IS : 7305 (Part I)-1973* with the following additional details/modifications:

a) The voltage as specified in Table 5 shall be applied between:

   i) terminations, and

   ii) terminations connected together and the case (where metallic) or the metal foil wrapped around the body (where the capacitor is insulated).

NOTE — The voltage shall not be applied gradually but shall be applied at once through the internal resistance of the test apparatus. The product of this internal resistance (in megohms) and the rated capacitance value (in microfarads) of the capacitor under test shall not exceed one second. The charging current shall not exceed 0·05 A.

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*Specification for fixed capacitors used in electronic equipment: Part I General requirements and tests.

TABLE 5 TEST VOLTAGE FOR INSULATION RESISTANCE MEASUREMENT

(*Clause* 9.3.3)

RATED VOLTAGE (U_R) (1) Volts	MEASURING VOLTAGE (2) Volts
$U_R < 100$	10 ± 1
$100 \leqslant U_R < 500$	100 ± 15
$U_R \geqslant 500$	500 ± 50

b) *Requirements* — The insulation resistance shall not be less than the values specified below:

Climatic Category (*see* **4.2**)	R_1 (M Ω)	$R_1 C_R$ (seconds)
1	10 000	250
2 and 3	4 000	100

9.3.4 *Voltage Proof* — This test shall be carried out in accordance with **7.3.1** of IS : 7305 (Part I)-1973* with the following additional details/modification:

a) A direct voltage of the value specified in Table 6 applied for a period of one minute ± 5 seconds, between:

  i) Terminations, and

  ii) Terminations connected together and the case (where metallic) or metal foil wrapped over the body (where the capacitor is insulated).

NOTE — The product of the internal resistance and the rated capacitance value of the capacitor under test plus any parallel capacitance in the test apparatus shall not exceed one second. The charging current shall not exceed 0·05A.

b) When this test is called for as flash test, the voltage shall be applied for two seconds.

c) *Requirements* — The capacitor shall withstand this test without breakdown or flash-over.

TABLE 6 VOLTAGE FOR VOLTAGE PROOF TEST

RATED VOLTAGE (U_R) (1) Volts	TEST VOLTAGE (2) Volts
$\leqslant 500$	$2{\cdot}5\ U_R$
> 500	$1{\cdot}5\ U_R + 500$

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*Specification for fixed capacitors used in electronic equipment: Part I General requirements and tests.

9.3.5 *Temperature Characteristic of Capacitance*

9.3.5.1 *Preconditioning* — The capacitors shall be preconditioned in accordance with **9.2.1**.

9.3.5.2 *Measuring conditions* — The capacitors shall be maintained at each of the temperatures mentioned below, under the condition stated against each:

Temperature	*Rated Voltage*	*Temperature Reference*
27 ± 2°C	—	*a*
Lower category temperature ± 3°C	—	*b*
27 ± 2°C	—	*d*
Upper category temperature ± 2°C	—	*f*
Upper category temperature ± 2°C	×	*f*
27 ± 2°C	×	*g*
Lower category temperature ± 3°C	×	*b*
27 ± 2°C	—	*a*

NOTE 1 — × indicates : Rated voltage applied
— indicates : No rated voltage applied

NOTE 2 — Measurements shall be made at such intermediate temperature as to ensure that the requirements of **5.1.1** are met.

NOTE 3 — The capacitance for reference is measured at temperature reference *d*.

NOTE 4 — Because of the effects described in **9.2.1** the capacitance values measured at temperature reference *f*, *a* and *b* with rated voltage applied, are time dependent. This time dependency is included in the given limits of capacitance change.

The capacitance change between the first and the last measurements at temperature reference *a* indicates the amount of ageing involved.

In case of dispute about results of measurements with rated voltage applied it is advisable to agree upon a fixed time interval between measurements at temperature reference *f* and *b*.

9.3.5.3 Capacitance measurements shall be made at each of the temperatures specified in **9.3.5.2** after the capacitor has reached thermal stability. The condition of thermal stability shall be judged to have been reached when two readings of capacitance taken at an interval of not less than 5 minutes do not differ by an amount greater than that which can be attributed to the measuring apparatus. Care must be taken during measurements to avoid condensation or frost on the surface of the capacitors.

9.3.5.4 *Requirements* — The temperature characteristic with or without rated voltage applied shall not exceed the value given in the relevant detail specifications.

9.4 Physical and Mechanical Tests

9.4.1 *Visual Examination* — The capacitors shall be visually examined for compliance with requirement of marking and finish.

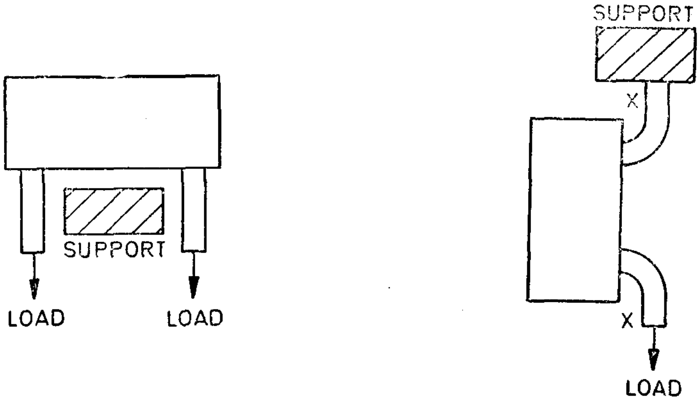
9.4.2 *Dimensions* — The dimensions shall be checked for compliance with those specified in the relevant detail specification.

9.4.3 *Robustness of Terminations*

9.4.3.1 *Tensile test* — This test shall be carried out in accordance with **7.4.3.1** of IS : 7305 (Part I)-1973* with the following additional details/modifications, for capacitors with radial wire terminations:

a) *When load is applied radially,* the body of the component shall be supported and the terminations shall be loaded. The loading mass shall be 500 g and applied gradually (*see* Fig. 1A).

b) *When load is applied axially,* the leads shall be bended close to the capacitor body so that they become located in the same plane as the capacitor body. The load shall be stress free at the point indicated by 'X' (*see* Fig. 1B). The loading mass shall be 250 g and applied gradually.



1A Radial Load 1B Axial Load

FIG. 1 ARRANGEMENT FOR TENSILE TEST

9.4.3.2 *Bending* (*for axial wire terminations only*) — This test shall be carried out in accordance with **7.4.3.2** of IS : 7305 (Part I)-1973*.

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*Specification for fixed capacitors used in electronic equipment : Part I General requirements and tests.

9.4.3.3 *Torsion (for axial wire terminations only)* — This test shall be carried out in accordance with **7.4.3.3** of IS : 7305 (Part I)-1973*.

9.4.3.4 *Torque (for nuts and threaded terminations)* — This test shall be carried out in accordance with **7.4.3.4** of IS : 7305 (Part I)-1973*.

9.4.3.5 *Requirements* — There shall not be any visible damage after any of these tests.

9.4.4 *Soldering*

9.4.4.1 *Solderability of terminations* — This test shall be carried out in accordance with **7.4.4** of IS : 7305 (Part I)-1973*, with the following additional details/modifications:

a) *Measuring Conditions* — There shall be no predrying. Wetting time shall be as follows:

With activated flux	⩽ 2 seconds
With non-activated flux	⩽ 4 seconds

b) *Requirements* — The terminations shall get wet easily and the tinning shall be uniform and good.

9.4.4.2 *Resistance to soldering heat* — This test shall be carried out in accordance with **7.8.2.5** of IS : 589-1961† with the following additional details/modifications:

a) *Preconditioning* — The capacitors shall be subjected for 1 hour to the upper category temperature followed by 24 hours under standard atmospheric conditions.

b) *Measuring conditions* :

Temperature of the bath	260 ± 5°C
Duration of immersion	10 seconds for components for general use 5 seconds for components specially designed for printed wiring applications
Recovery	1 to 2 hours

c) *Requirements* — There shall be no visible damage and marking shall be legible. The percentage change in capacitance shall not exceed the following values when compared with the value measured in **9.3.1** (*see also* Table 1):

± 10 percent	for classes B and C
± 15 percent	for class D
± 20 percent	for classes E and F

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*Specification for fixed capacitors used in electronic equipment : Part I General requirements and tests.

†Basic climatic and mechanical durability tests for electronic components (*revised*).

9.4.5 *Vibration* — This test shall be carried out in accordance with **7.4.5** of IS : 7305 (Part I)-1973*, with the following additional details/ modifications:

a) *Mounting* — The mounting shall be as prescribed in the relevant detail specifications.

b) *Conditioning* — The severity shall be as specified in the relevant detail specification chosen from the following:

Frequency (Hz)	*Peak Value of Vibration* Amplitude ± 10 percent	*Duration* hours	*Climatic Category* (*see* **4.2**)
10-2 000	0·75 mm or 20 g whichever is less	12	1A
10-2 000	0·75 mm or 10 g whichever is less	9	1B & 2
10-500	0·75 mm or 10 g whichever is less	6	3

c) *Measurements and requirements during testing* — Category 1 capacitors shall be loaded with rated voltage throughout the test During the last half an hour of vibration test in each direction electrical measurements shall be made in the capacitors to determine intermittent faults (open or short circuits). It is desirable that the detecting equipment shall detect any interruption with a duration of 0·5 millisecond or greater. There shall be no interruption.

d) *Final inspection, measurements and requirements* — After the test the capacitors shall be visually examined and there shall be no mechanical damage. Marking shall be legible.

The capacitance, tangent of loss angle and leakage current shall be measured. The variation shall be within the limits specified in the relevant detail specification.

9.4.6 *Bump* — This test shall be carried out in accordance with **7.4.7** of IS : 7305 (Part I)-1973*, with the following additional details/ modifications:

a) *Mounting* — The mounting shall be as prescribed in the relevant detail specifications.

b) *Conditioning* — The degree of severity shall be:

i) 4 000 bumps for category 1, and

ii) 1 000 bumps for categories 2 and 3.

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*Specification for fixed capacitors used in electronic equipment : Part I General requirements and tests.

c) *Measurements and requirements during testing* — Category 1 capacitors shall be loaded with rated voltage throughout the test. During the last half an hour of vibration test in each direction electrical measurements shall be made on the capacitors to determine intermittent faults (open or short circuits). It is desirable that the detecting equipment shall detect any interruption with a duration of 0·5 millisecond or greater. There shall be no interruption.

d) *Final inspection, measurements and requirements* — After the test the capacitor shall be visually examined and there shall be no mechanical damage. Marking shall be legible.

The capacitance, tangent of loss angle and leakage current shall be measured. The variation shall be within the limit specified in the relevant specification.

9.4.7 *Shock* — This test shall be carried out in accordance with **7.4.8** of IS : 7305 (Part I)-1973*, with the following additional details/modifications:

a) *Mounting* — The mounting shall be as prescribed in the relevant detail specification.

b) *Conditioning* — The degree of severity shall be as specified in the relevant detail specification.

c) *Measurements and requirements during testing* — Category 1 capacitors shall be loaded with rated voltage throughout the test. During the last half an hour of vibration test in each direction electrical measurements shall be made on the capacitors to determine intermittent faults (open or short circuits). It is desirable that the detecting equipment shall detect any interruption with a duration of 0·5 millisecond or greater. There shall be no interruption.

d) *Final inspection, measurements and requirements* — After the test the capacitor shall be visually examined and there shall be no mechanical damage. Marking shall be legible.

The capacitance, tangent of loss angle and leakage current shall be measured. The variation shall be within the limit specified in the relevant specification.

9.4.8 *Acceleration* — This test shall be carried out in accordance with **7.4.9** of IS : 7305 (Part I)-1973*, with the following additional details/modifications:

a) *Mounting* — The mounting shall be as prescribed in the relevant detail specification.

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*Specification for fixed capacitors used in electronic equipment: Part I General requirements and tests.

b) *Conditioning* — The degree of severity shall be as specified in the relevant detail specification.

c) *Measurements and requirements during testing* — Category 1 capacitors shall be loaded with rated voltage throughout the test. During the last half an hour of vibration test in each direction electrical measurements shall be made on the capacitors to determine intermittent faults (open or short circuits). It is desirable that the detecting equipment shall detect any interruption with a duration of 0·5 millisecond or greater. There shall be no interruption.

d) *Final inspection, measurements and requirements* — After the test the capacitor shall be visually examined and there shall be no mechanical damage. Marking shall be legible.

The capacitance, tangent of loss angle and leakage current shall be measured. The variation shall be within the limit specified in the relevant specification.

9.5 Climatic Tests

9.5.1 *Climatic Sequence* — This test shall be carried out in accordance with **7.5.1** of IS : 7305 (Part I)-1973* with the following additional details/modifications.

9.5.1.1 *Preconditioning* — The capacitors shall be subjected to the upper category temperature for 1 hour followed by 24 hours under standard atmospheric conditions.

9.5.1.2 *Initial measurement* — The capacitance shall be measured in accordance with **9.3.1**.

9.5.1.3 *Dry heat* — This test shall be carried out in accordance with **7.5.1.2** of IS : 7305 (Part I)-1973* using the appropriate degree of severity. Duration of the test shall be 16 hours unless otherwise specified in the relevant detail specification.

Half the samples shall be loaded with rated voltage. While the capacitors are still in test chamber, insulation resistance shall be measured, for category 1 and 2. Insulation resistance shall not be less than 100 MΩ for category 1A and 500 MΩ for category 1B and 2.

After recovery the capacitors shall be visually examined. There shall be no visible damage and marking shall be legible.

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*Specification for fixed capacitors used in electronic equipment: Part I General requirements and tests.

9.5.1.4 *Damp heat (accelerated), first cycle* — This test shall be carried out in accordance with **7.5.1.3** of IS : 7305 (Part I)-1973*.

After recovery the capacitors shall be visually examined. There shall not be any visible damage. Marking shall be legible. The capacitors then immediately be subjected to cold test.

9.5.1.5 *Cold* — This test shall be carried out in accordance with **7.5.1.4** of IS : 7305 (Part I)-1973*. The duration of exposure shall be two hours unless otherwise specified in relevant detail specification.

After recovery, the capacitors shall be visually examined. There shall be no visible damage and marking shall be legible and indelible.

9.5.1.6 *Low air pressure* — This test shall be carried out in accordance with **7.5.1.5** of IS : 7305 (Part I)-1973*, with the following additional details/modifications:

a) *Measuring conditions* — The measuring conditions shall be:
   i) 1 to 2 minutes at 4·4 kPa
   ii) Temperature 15 to 35°C
   iii) Rated voltage U_R applied during 1 to 2 minutes, immediately after achieving the pressure of 4·4 kPa.

b) *Requirement* — There shall be no breakdown or flashover.

9.5.1.7 *Damp heat (accelerated), remaining cycles* — This test shall be carried out in accordance with **7.5.1.6** of IS : 7305 (Part I)-1973* with the following additional details/modifications:

a) *Measuring conditions* — The measuring conditions shall be:
   i) No voltage application
   ii) Number of cycles of 24 hours each — 5 for category 1
   1 for category 2
   None for category 3

9.5.1.8 *Final inspection, measurement and requirements* — After a recovery period of 24 ± 2 hours capacitors shall be visually examined. There shall be no visible damage and marking shall be legible.

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*Specification for fixed capacitors used in electronic equipment : Part I General requirements and tests.

The capacitance, tangent of loss angle and insulation resistance shall be measured and shall meet the following requirements:

Measurement	*Measuring Condition Ref Clause*	*Requirement*		
		Classes B & C	Class D	Classes E & F
$\frac{\Delta C}{C}$	9.3.1.1	$< \pm 10$ percent	$< \pm 15$ percent	$< \pm 20$ percent
Tangent of loss angle	9.3.2	$\leqslant 50 \cdot 10^{-3}$	$\leqslant 70 \cdot 10^{-3}$	$\leqslant 70 \cdot 10^{-3}$
Insulation resistance	9.3.3	10 000 MΩ for category 1 1 000 MΩ for categories 2 and 3	10 000 MΩ for category 1 1 000 MΩ for categories 2 and 3	10 000 MΩ for category 1 1 000 MΩ for categories 2 and 3

9.5.2 *Damp Heat (Long Term)* — This test shall be carried out in accordance with **7.5.2** of IS : 7305 (Part I)-1973* with the following additional details/modifications:

a) *Preconditioning* — The capacitor shall be subjected to the upper category temperature for one hour followed by 24 hours under standard atmospheric conditions.

b) *Initial measurements* — The capacitance shall be measured.

c) *Measuring conditions* — Voltage shall not be applied unless otherwise specified in the relevant detail specification.

d) *Final inspection, measurements and requirements* — After a recovery period of 24 ± 2 hours the capacitors shall be visually examined. There shall be no visible damage and marking shall be legible.

The capacitance, tangent of loss angle, insulation resistance shall be measured and shall meet the following requirements:

Measurement	*Measuring Condition Ref Clause*	*Requirement*		
		Classes B & C	Class D	Classes E & F
$\frac{\Delta C}{C}$	9.3.1.1	$<$ 10 percent	$<$ 15 percent	$<$ 20 percent
Tangent of loss angle	9.3.2	$\leqslant 50 \cdot 10^{-3}$	$\leqslant 70 \cdot 10^{-3}$	$\leqslant 70 \cdot 10^{-3}$
Insulation resistance	9.3.3	10 000 MΩ for category 1 1 000 MΩ for categories 2 and 3	10 000 MΩ for category 1 1 000 MΩ for categories 2 and 3	10 000 MΩ for category 1 1 000 MΩ for categories 2 and 3

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*Specification for fixed capacitors used in electronic equipment : Part I General requirements and tests.

9.5.3 *Rapid Change of Temperature* — This test shall be carried out in accordance with **7.5.3** of IS : 7305 (Part I)-1973*, with the additional details/modifications:

a) *Preconditioning* — The capacitance shall be subjected for one hour to the upper category temperature followed by 24 hours under standard atmospheric conditions.

b) *Initial measurements* — The capacitance shall be measured.

c) *Measuring conditions*:

  i) Number of cycles shall be 5 with 30 minutes at each extreme temperature,

  ii) Recovery shall be of 24 ± 2 h under standard atmospheric conditions.

d) *Final inspection, measurements and requirements*:

  i) The capacitors shall be visually examined and there shall be no visible damage.

  ii) The capacitance shall be measured in accordance with **9.3.1.** The percentage change in capacitance shall not exceed the following:

± 10 percent for classes B & C
± 15 percent for class D
± 20 percent for classes E & F

  iii) The capacitors shall be subjected to voltage proof test. The capacitors shall withstand this test without breakdown or flash-over.

9.5.4 *Salt Mist (Applicable to Feed-Through and Stand-Off Types Only)* — This test shall be carried out in accordance with **7.5.5** of IS : 7305 (Part I)-1973*. The duration of the exposure shall be four days.

The capacitors shall be visually examined. There shall be no visible damage and marking shall be legible.

9.5.5 *Mould Growth* — This test shall be carried out in accordance with **7.5.4** of IS : 7305 (Part I)-1973*. The capacitors shall be visually examined. There shall not be any mould growth visible to naked eye.

9.6 Miscellaneous Tests

9.6.1 *Storage (Normal)* — Under consideration.

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*Specification for fixed capacitors used in electronic equipment: Part I General requirements and tests.

9.6.2 *Endurance* — This test shall be carried out with **7.9** of IS : 7305 (Part I)-1973* with following details:

a) *Preconditioning* — The capacitors shall be subjected for one hour to the upper category temperature followed by 24 hours under standard atmospheric conditions.

b) *Initial measurement* — The capacitance shall be measured in accordance with **9.3.1.**

c) *Measuring conditions* — The conditions for endurance test shall be:

i) Temperature	Upper category temperature
ii) Voltage applied	$1{\cdot}5\ U_R$
iii) Duration	2 000 hours with rated voltage applied for category 1, and 1 000 hours for categories 2 & 3 with no voltage applied

d) *Final inspection, measurements and requirements* — After a recovery period of 24 ± 2 h the capacitors shall be visually examined and there shall be no visible damage and marking shall be legible.

The capacitance, tangent of loss angle and insulation resistance shall be measured and shall meet the following requirements:

Measurement	*Measuring Condition Ref Clause*	*Requirement*		
		Classes B & C	Class D	Classes E & F
$\frac{\Delta C}{C}$	9.3.1.1	$\leqslant$ 20 percent	$\leqslant$ 20 percent	$\leqslant$ 20 percent
Tangent of loss angle	9.3.2	$\leqslant 50 \cdot 10^{-3}$	$\leqslant 70 \cdot 10^{-3}$	$\leqslant 70 \cdot 10^{-3}$
Insulation resistance	9.3.3	10 000 MΩ for category 1 2 000 MΩ for categories 2 and 3	10 000 MΩ for category 1 2 000 MΩ for categories 2 and 3	10 000 MΩ for category 1 2 000 MΩ for categories 2 and 3

9.6.3 *Resistance to Solvents* — This test shall be carried out in accordance with IS : 9000 (Part XX)-1979†.

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*Specification for fixed capacitors used in electronic equipment: Part I General requirement and tests.

†Basic environmental testing, procedures for electric and electronic items: Part XX Resistance to cleaning solvents and permanence of workings.

APPENDIX A

[*Clauses* 9.2.1 *and* 9.3.1 (c)]

CAPACITANCE AGEING OF FIXED CERAMIC DIELECTRIC CAPACITORS, TYPE 2

A-1. INTRODUCTION

A-1.1 Most type 2 dielectrics used for ceramic capacitors are ferroelectric, exhibiting a ferroelectric Curie temperature. Above this temperature the dielectric has the highly symmetric cubic crystal structure whereas below the Curie temperature the crystal structure is less symmetrical. Although in single crystals this phase transition is very sharp, in practical ceramics it is often spread over a finite temperature range, but in all cases it is linked with a peak in the capacitance/temperature curve.

Under the influence of thermal vibration the ions in the crystal lattice continue to move to positions of lower potential energy for a long time after the dielectric has cooled through the Curie temperature. This gives rise to the phenomenon of *capacitance ageing*, whereby the capacitor continually decreases its capacitance. However, if the capacitor is heated to a temperature above the Curie temperature, then de-ageing takes place, that is, the capacitance lost through ageing is regained, and ageing recommences from the time when the capacitor re-cools.

A-2. THE LAW OF CAPACITANCE AGEING

A-2.1 During the first hour after cooling through the Curie temperature the loss of capacitance is not well defined, but after this time it follows a logarithmic law which can be expressed in terms of an ageing constant.

The ageing constant k is defined as the percentage loss of capacitance due to the ageing process of the dielectric which occurs during a ‘ decade ’ that is, a time in which the capacitor increased its age tenfold, for example, from 1 to 10 hours. As the law of decrease of capacitance is logarithmic the percentage loss of capacitance will be 2 k between 1 hour and 100 hours age and 3 k between 1 hour and 1 000 hours age. This may be expressed mathematically by the following equation:

$$C_t = C_1 \left(1 - \frac{k}{100} \cdot \log_{10} t \right)$$

where

C_t is the capacitance t hours after the start of the ageing process,

C_1 is the capacitance 1 hour after the start of the ageing process,

k is the ageing constant in percent per decade (as defined above), and

t is the time in hours from the start of the ageing process.

The ageing constant may be declared by the manufacturer for a particular ceramic dielectric, or it may be determined by de-ageing the capacitor and measuring the capacitance at two known times thereafter.

k is then given by the following equation:

$$k = \frac{100\,(C_{t_1} - C_{t_2})}{C_{t_1} \log_{10} \frac{t_2}{t_1}}$$

If capacitance measurements at three or more times are made, then it is not necessary to de-age the capacitor beforehand, but the calculation is a little more complicated since the time zero is not known and must be inferred from the data. During measurements of ageing the capacitor should be maintained at a constant temperature so that capacitance variations due to the temperature characteristic do not mask those due to ageing.

A-3. CAPACITANCE MEASUREMENTS AND CAPACITANCE TOLERANCE

A-3.1 Because of ageing it is necessary to specify an age for reference measurements at which the capacitance shall be within the prescribed tolerance. This is fixed at 1 000 h, since for practical purposes there is not much further loss of capacitance after this time.

In order to calculate the capacitance $C_{1\,000}$ after 1 000 hours the ageing constant must be known or determined as given in **A-2.1** when the following formula may be used:

$$C_{1\,000} = C_t\left[1 - \frac{k}{100}\left(3 - \log_{10} t\right)\right]$$

For routine measurements by manufacturers the loss of capacitance from the age at time of measurement to 1 000 hours age will be known and may be off-set by using asymmetric inspection tolerances. For example, if it is known that the capacitance loss will be 5 percent then the capacitors may be inspected to limits of + 25/−15 percent instead of ± 20 percent.

Capacitance is normally declared at 27°C, and it may be necessary to measure at this temperature or correct the results to this temperature. Errors may also arise from heat from the hands, and capacitors should therefore always be handled by tweezers.

A-4. SPECIAL PRECONDITIONING

A-4.1 In many of the tests in this standard it is required to measure the capacitance change which results from a given conditioning (for example, climatic sequence). In order to avoid the interfering effect of ageing the capacitor is preconditioned before these tests by maintaining it for 1 hour at the upper category temperature followed by 24 hours at standard atmospheric conditions. For those capacitors with a Curie temperature below the upper category temperature this results in de-ageing and subsequently bringing the capacitors to an age of 24 hours.

The recovery after the conditioning is also arranged if possible to bring the capacitors to an age of 24 hours, so that capacitance changes due to ageing are minimized.

If the Curie temperature of the dielectric is above the upper category temperature then the special preconditioning will not completely de-ageing the capacitor, but it will nevertheless bring it into a state where its capacitance is not so dependent on its previous history, and the same effect will be achieved, though the ageing state will not be the same as if the capacitor had been completely de-aged. In order completely to de-age such capacitors temperature up to 160°C may be required, and this temperature could be deleterious to the encapsulation. Therefore in the few cases where complete de-ageing of such capacitors may be required the detail specification should be consulted for details and any necessary precautions.

INDIAN STANDARDS
ON
CAPACITORS

IS:

590-1964 Fixed paper dielectric capacitors for dc (*revised*)
824-1965 Preferred values for resistors and capacitors
1885 (Part XLV)-1977 Electrotechnical vocabulary: Part XLV Capacitors
2001-1968 Fixed silvered mica capacitors (*first revision*)
2786 (Part I)-1978 Ceramic dielectric capacitors, Type 2: Part I General requirements and methods of test (*first revision*)
3671 (Part I)-1968 Air dielectric variable capacitors: Part I Tests and general requirements
3723 (Part I)-1978 Capacitors for radio interference suppression: Part I General requirements and methods of tests
4317 (Part I)-1978 Aluminium electrolytic capacitors: Part I General requirements and tests
4633-1968 Fixed metallized-paper dielectric capacitors for direct current
5361-1969 Polyester film dielectric capacitors for direct current
5475 (Part I)-1978 Polystyrene film dielectric capacitors: Part I General requirements and methods of tests
7305 (Part I)-1973 Fixed capacitors used in electronic equipment: Part I General requirements and tests
7305 (Part II)-1975 Fixed capacitors used in electronic equipment: Part II Ceramic dielectric capacitors, Type I
7748 (Part I)-1975 Variable capacitors: Part I Tests and general requirements
8083-1976 Dimensions of ceramic dielectric capacitors of the plate type
8186-1976 Marking codes for values and tolerances of resistors and capacitors
8238-1976 Guide for use of variable capacitors in electronic equipment
8507 (Part I)-1977 Fixed tantalum capacitors with solid electrolyte: Part I General requirements and methods of tests

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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